ALASKA'S CAPSTONE PROGRAM
Integrating Communications, Navigation and Surveillance

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April 2004

Capstone: The Need, The Origins

- **NIOSH[1]: Aviation accident rate four times the national average**
- **NTSB: 1995 safety study recommended a "model program" to**
  - **Use Global Positioning System (GPS) as sole means of navigation; en route and non-precision approaches**
  - **Use satellite based data link, voice communication: aircraft to/from air traffic control (ATC)**
  - **Use single engine turbine aircraft for commercial passenger flights**
  - **Use current uncontrolled airspace for instrument flight rules (IFR)**
- **Named from the program's effect of drawing and holding together concepts/recommendations contained in reports from RTCA, NTSB, etc.**

Note 1: NIOSH-National Institute of Occupational Safety and Health

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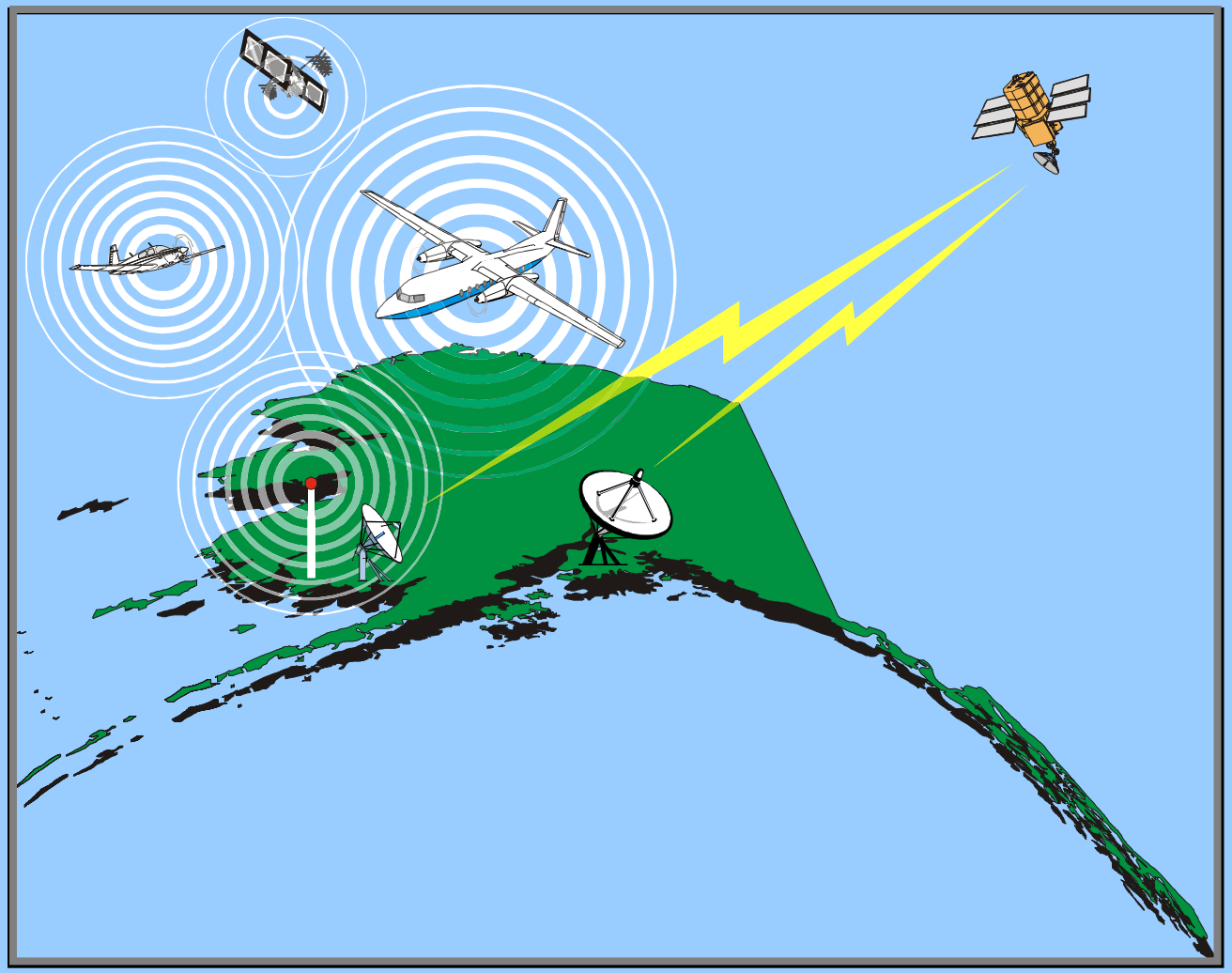
Capstone's Response: "Bundled" Technology

- GPS nav
- Terrain data
- ADS-B Air/Air
- TIS-B Gnd/Air
- FIS-B incl Wx
- "Radar-Like" Air Tfc Service
- Flight Following
- AWOS
- Approaches, Routes
- Measurement



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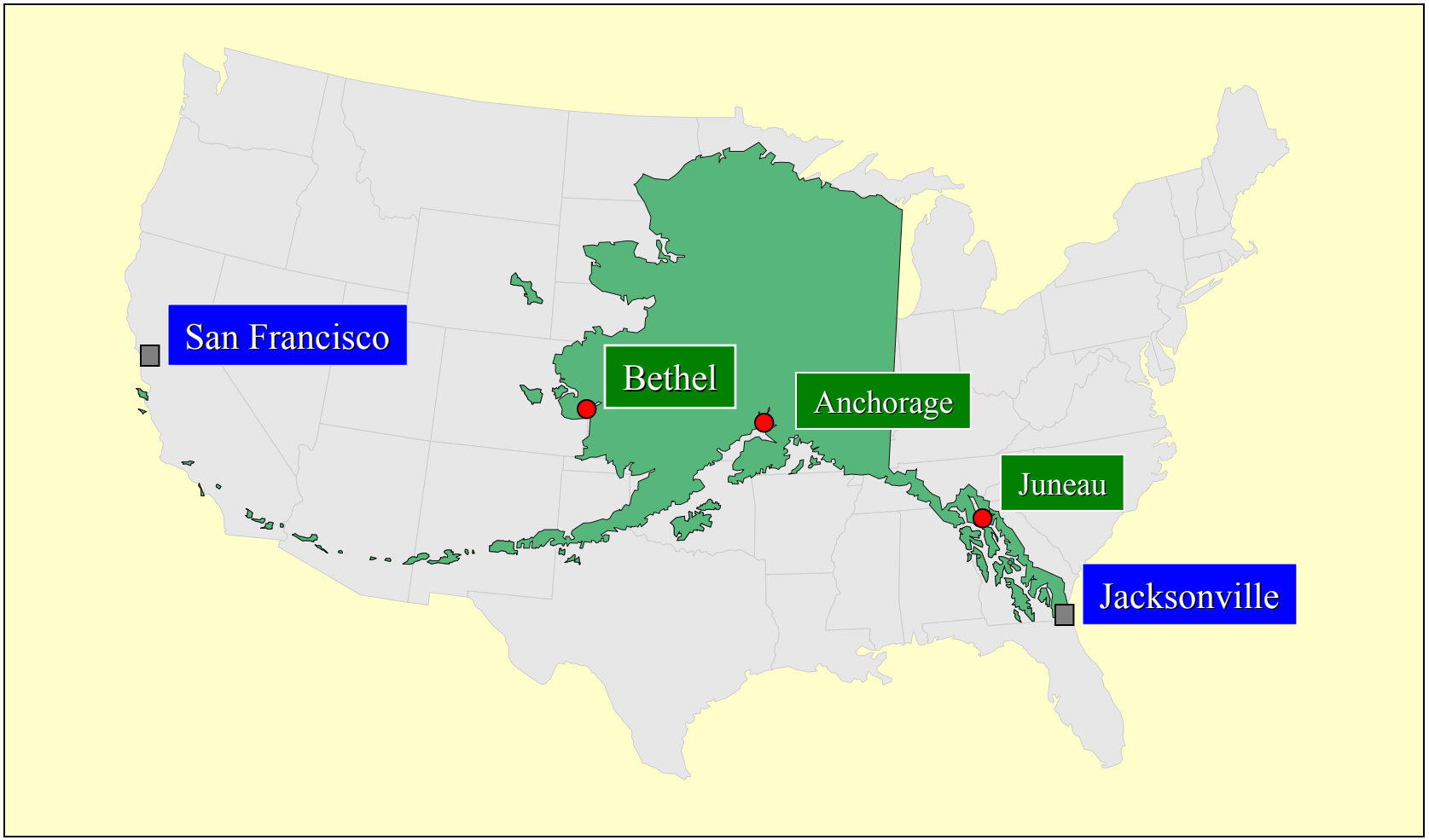
The Job – In Perspective



Communities Served by Capstone

McGrath on the Kuskokwim

Unalakleet: Bering Sea

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Communities Served- continued

McGrath Waterfront

McGrath Shopping

Aniak Suburbs

Anvik on Yukon

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Alaska Aviation – The Needs

The Rocks: Merrill Pass

The Weather

The Airports: Wet and Dry

The Goods

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Communities – The Planes That Serve

Aniak Flight Line

Anchorage – Lake Hood

Juneau Floatplanes

Commercial Flight Line at Bethel

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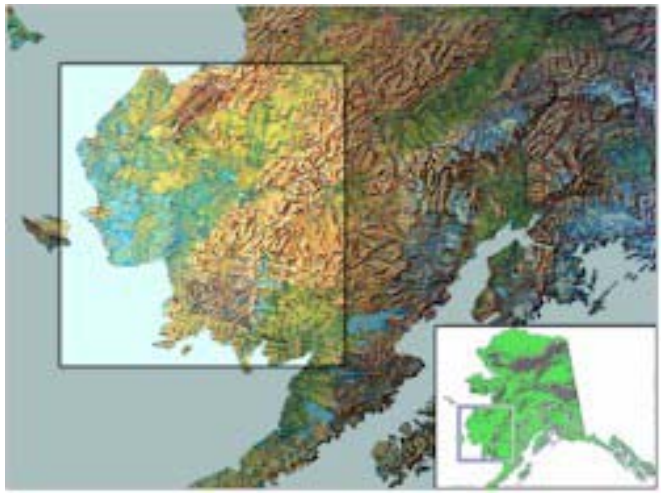
Capstone Near-term Goals, Program Scope

- **Safety and efficiency improvements by accelerating the implementation and use of technology**
  - **Implements NTSB's "model demonstration program"**
  - **Continually monitors feedback from user community**
  - **Includes training for pilots, controllers, and maintenance personnel**
  - **Coordinates installation of more weather sensors and communications outlets, airport lighting for instrument approaches**

Capstone Phase I



The Region

Bethel, AK

The Yukon – The 'Other' Highway

Bethel – Yukon/Kuskokwim Delta

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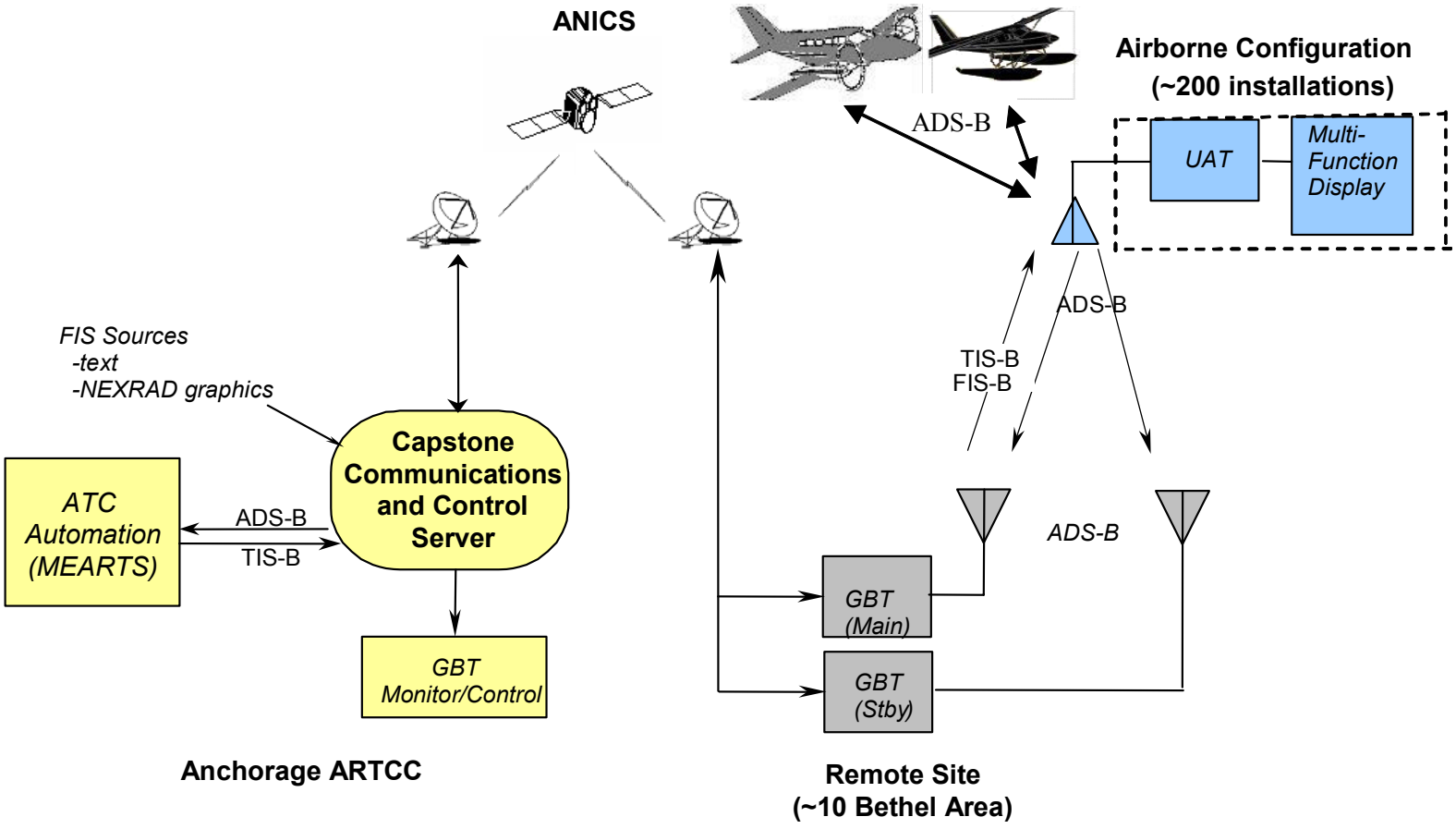
Capstone I – A System of Systems

- Avionics with GPS, terrain database
- Universal Access Transceiver (UAT) data link
  - Automatic Dependent Surveillance – Broadcast (ADS-B) air-air
  - Traffic Information Service-Broadcast (TIS-B) ground-air
  - ADS-B air-ground (ATC surveillance)
  - Up-linked weather
- Ground system
  - Ground-based transceivers (UAT and processor)
  - Surface and satellite telecommunications
  - Processing and interface with ATC automation system
- Supporting components
  - Automated weather observation sites (AWOS)
  - Additional communications
- Aggressive implementation schedule (two years: start to operational use)
- Up to 200 avionics installations now accomplished

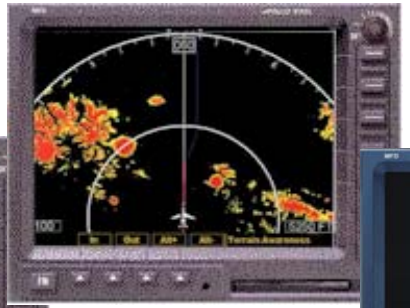
Capstone Phase I System Block Diagram



Capstone I Avionics

IFR En Route Chart

VFR Sectional Chart



Terrain Avoidance

Graphical Weather

Textual Weather

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UPS Aviation Technologies SM
A subsidiary of United Parcel Service

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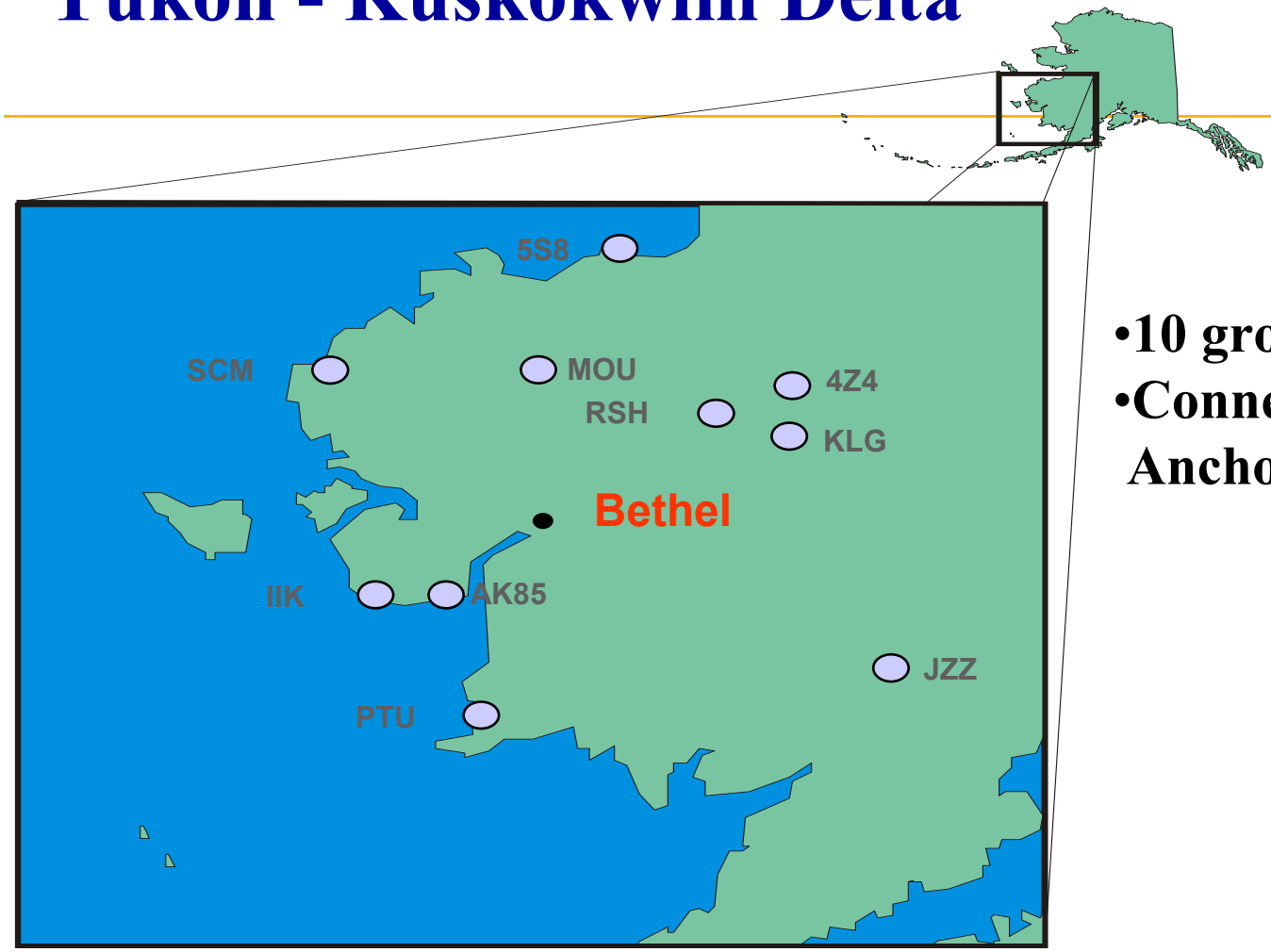
Current Capstone Ground System

- Network of 10 (+ 1) remote GBT sites
- Capstone Communications and Control Server (CCCS):
  - Operational system, developmental system
  - Routes critical ATC surveillance data
  - Processes and routes weather (FIS) and traffic (TIS) data
  - Connects to Micro En Route Automated Radar Tracking System (EARTS) ATC automation system
- Remote Maintenance Monitoring (RMM)
- ATC automation system upgrades, adaptations for ADS-B

Yukon - Kuskokwim Delta



- 10 ground stations
- Connects to Anchorage ARTCC

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Remote: Sparrevohn GBT and Radar Site

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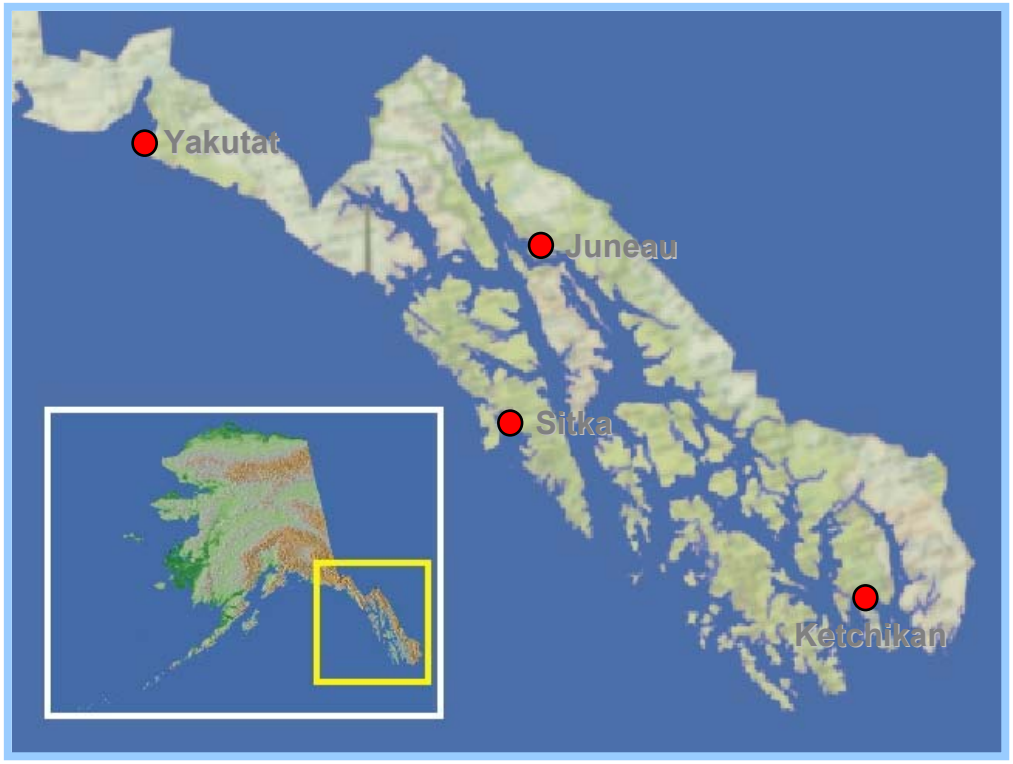
Phase I Timeline

- 1999
  - Avionics suites purchased
  - Airport surveys, plans for AWOS, instrument approaches
  - Capstone demonstration; avionics certification tasks began
- 2000
  - Training for pilots, controllers, maintenance technicians
  - Certification of avionics completed
  - Began GBT network installation
  - Engineering standards work underway
- 2001
  - First ever radar-like services using ADS-B, January 1st
- 2002-present: "Hardening" activities
  - Logistics/maintenance support activities
  - Merging systems into the NAS
  - Upgrades for Minimum Operational Performance Specification (MOPS) compliance

Significance of Phase I

- First permanent operational use of ADS-B for air traffic services
- Overcame institutional resistance to ADS-B for continued operation
- Safety improvements, accident reduction
  - Up to 25% reduction after two years for installed aircraft
  - Accidents consistently lower than the rate before equipping
  - Installations only recently neared 100% in Bethel area (Pt 135)
- Safety, utility for FAA and commercial operators
  - Flight following and flight plan monitoring

Capstone Phase II - Southeast Alaska



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Southeast Alaska – A Different Place

Rocks - lots of rocks

Low, wet weather

Low weather and rocks

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Phase II Objectives – New Uses for Area Navigation (RNAV)

- **Use GPS/WAAS for en route portion of flights in Alaska (AK)**
  - **Higher precision, availability of navigation signals**
  - **With AK terrain masking ground-based navaids, the GPS/Wide Area Augmentation System (WAAS) signals are more visible**
  - **Changes to Federal Aviation Regulations (SFAR[1] 97)**
    - **Permits satellite navigation as the only means of navigation**
    - **Allows the use of lower Minimum En route Altitudes (MEAs)**
    - **Promotes safety by creating a usable IFR structure**

      (Allows an IFR option for pilots who mostly fly VFR –and low!)
- **Establish new GPS/WAAS departure and approach procedures**
- **Establish entirely new GPS routes that avoid terrain**

Note 1: SFAR – Special Federal Aviation Regulation

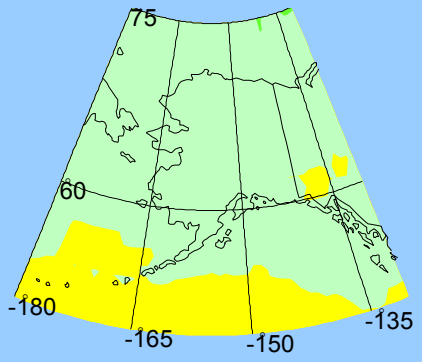
IFR Navigation Availability - Comparisons

- **Projected En Route Navigation Availability in Alaska**

0.985

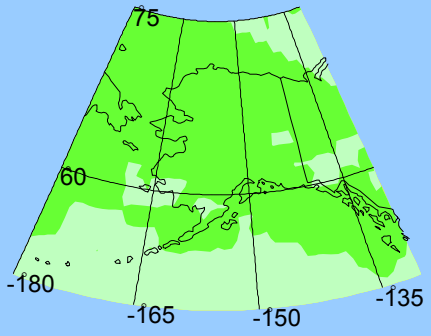
**Current VOR/NDB*
(Sisters Island)**

0.999

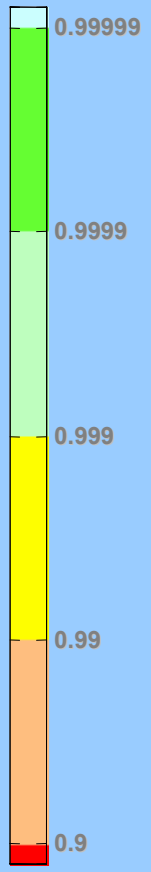


**RAIM with GPS and
Barometric Aiding****

0.9999



**Initial WAAS with
Barometric Aiding****



* NASPAS 6040-20 Facility and Service Outage Report, Data range ➔ 03/01/98 to 02/28/01

** "Projected GPS and Initial WAAS Horizontal Navigation Coverage in Alaska," MITRE/CAASD briefing 31 May 2001

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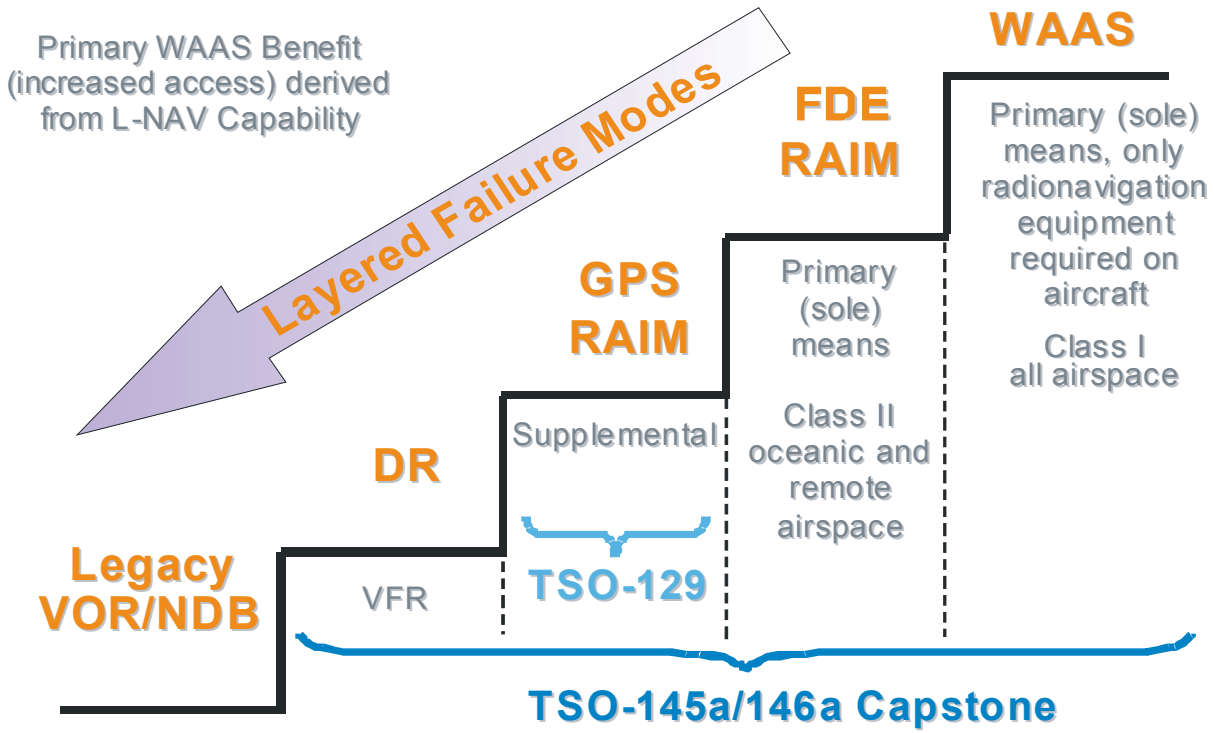
Degradation Modes for TSO-C145a/C146a GPS/WAAS Avionics



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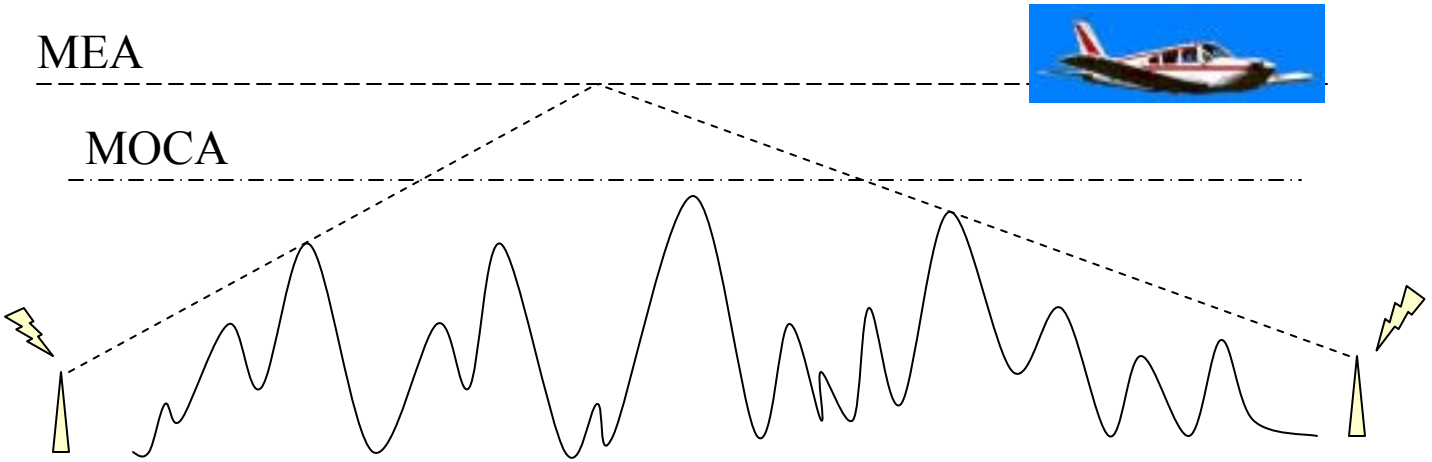
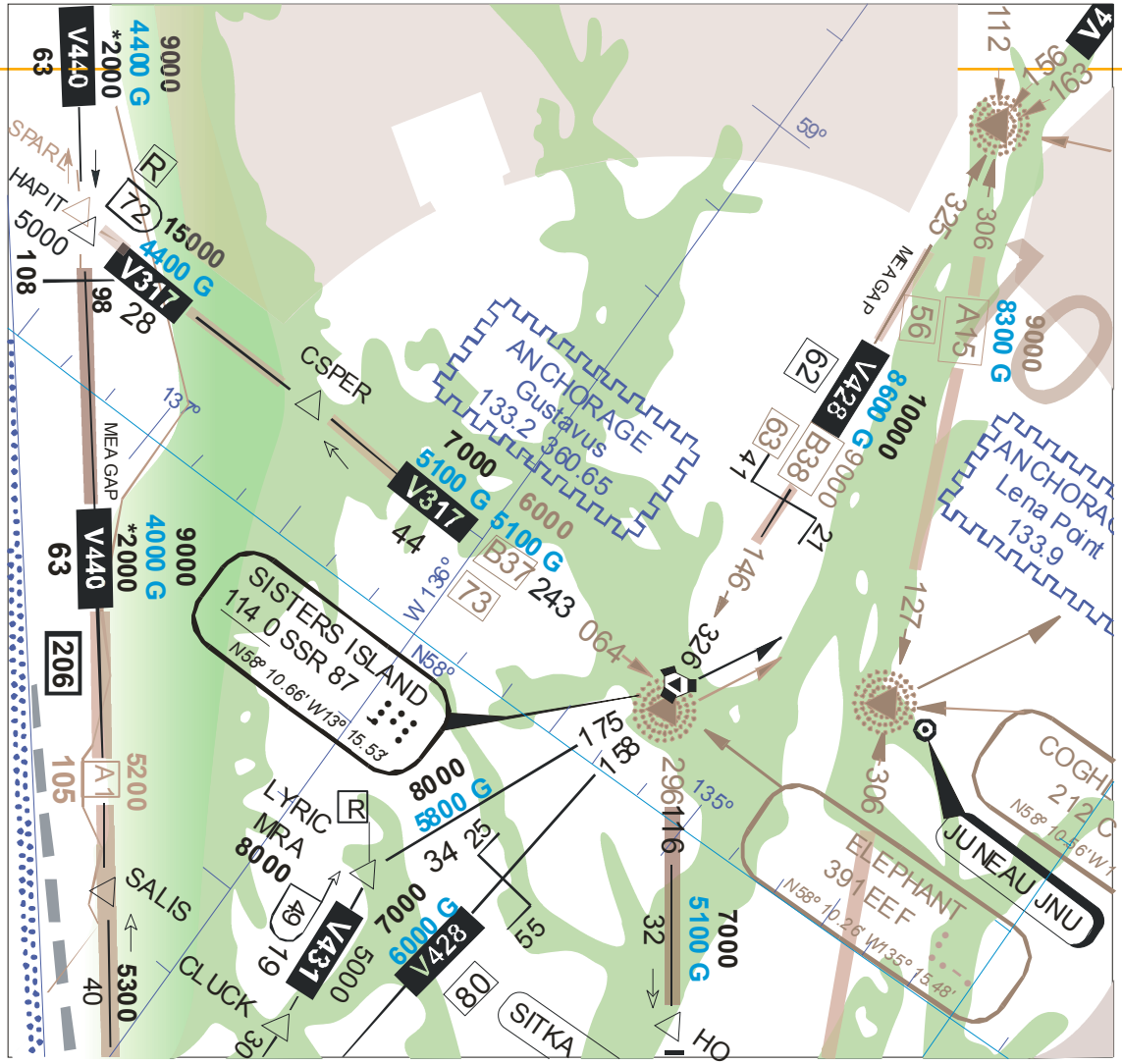
Mimimum Enroute Altitudes (MEAs) and Minimum Obstruction Clearance Altitudes (MOCAs)



Communication and navaids

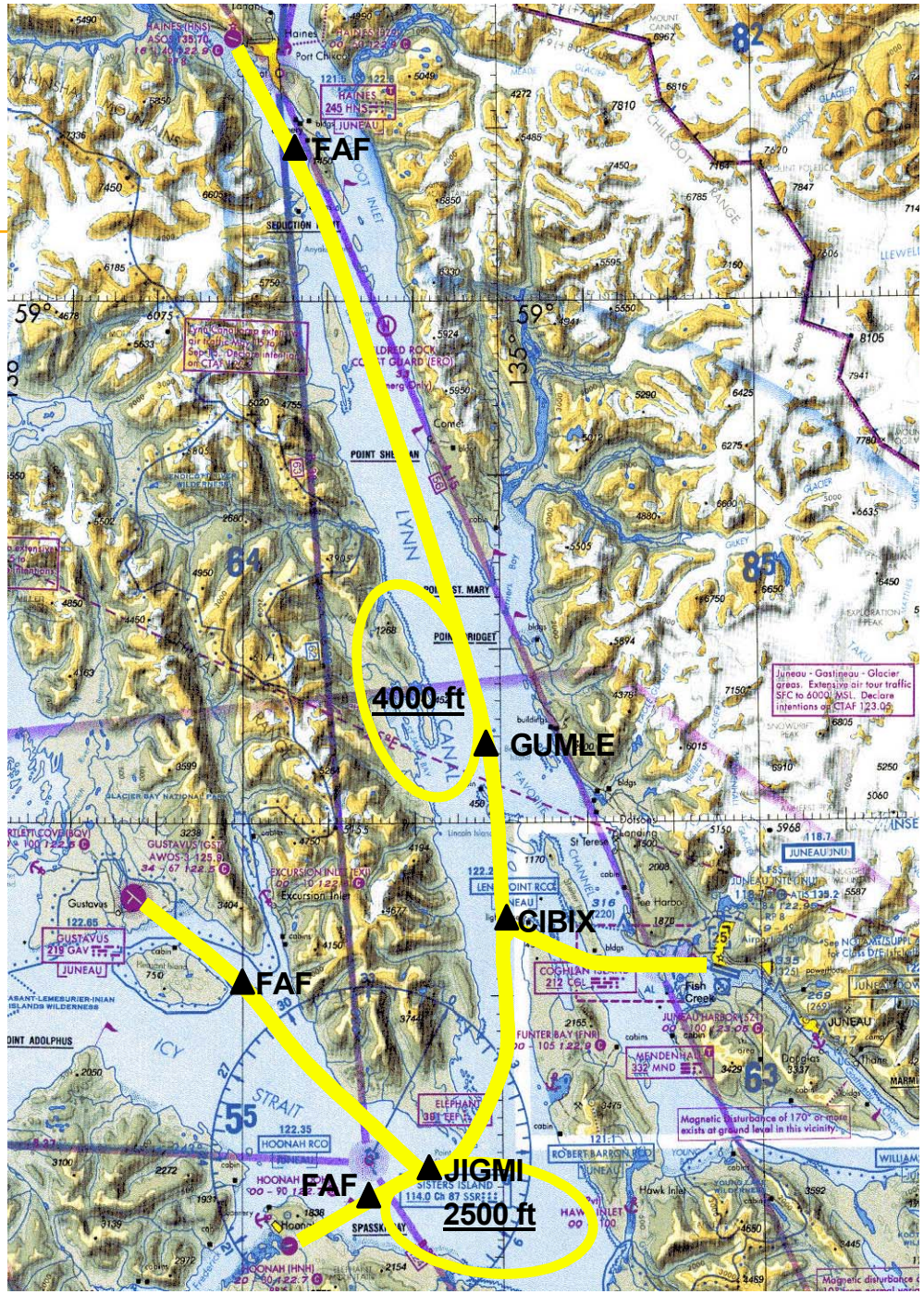
Extreme case: Route may be over water but navaids are obstructed by high terrain

Routes With Lower MEAs



Departure, Arrival Pairs

New, low RNAV routes will use waypoints to define the centerline of IFR flyways (e.g., bodies of water) rather than lines between two ground-based navaids



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Phase II: Adds New RNAV Operations

- **Chelton EFIS (Electronic Flight Information System) displays, configurable as**
  - **Three-dimensional, Primary Flight Display (PFD) with Highway In The Sky, forward-looking terrain or a**
  - **Multi-Function Display (MFD) that shows moving map, traffic, terrain or weather displays**
- **AHRS[1], ADC[2], AIU[3]**
- **SFAR 97 approves GPS/WAAS as "sole means" in AK for IFR en route RNAV operations at special MEAs**
- **New low-altitude routes following fiords, channels**

Notes:

1. **AHRS – Attitude, heading and reference system**
2. **ADC – Air data computer**
3. **AIU – Analog interface unit**

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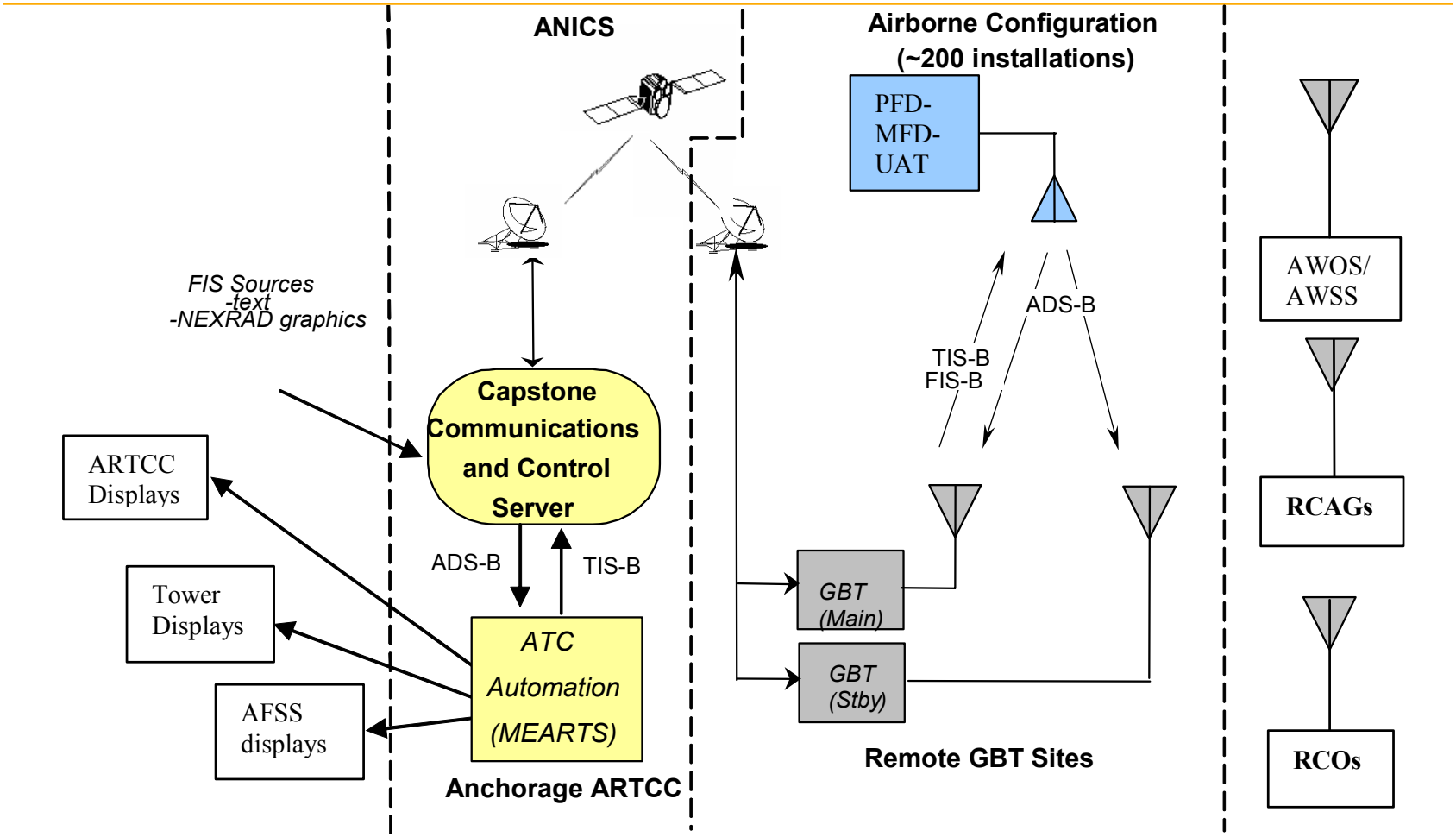
Capstone Phase II System Block Diagram



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Phase II avionics: JNU Approach - Short Final

Phase II Timeline

- March ‘02: meet with user community, validate needs
- March ‘03 - First avionics installations began
  - SFAR 97, new RNAV routes approved
  - Avionics certification
  - First commercial flight using GPS as “sole means” on optimized routes with lower MEAs (TSO 145a/146a)
- July ’03 - WAAS approved; first revenue flights
- Oct ‘04 - ADS-B data link avionics begin installations
- 2005 - GBT ground architecture installed; new ATC services

Significance of Phase II

- **Distinguishing feature: innovative use of RNAV**
- **Uses GPS/WAAS for "sole means" (transition from traditional ground-based navaids). It opens up:**
  - **RNAV routes with lower MEAs: *"First increment saved or lowered 41,000 feet of airspace along 1,521 nautical miles of the existing route structure."***
  - **New RNAV routes without "anchors" to ground navaids**
- **Expands the field of manufacturers of ADS-capable avionics**

Risks of Accelerated Implementation: Combining Innovative Technology With Aggressive Systems Engineering

- New technology: Bugs, bugs and more bugs
  - Software problems, frequent upgrades
  - Procedural problems - Some airworthiness issues
  - National standards issues: MOPS, ARINC 424 coding standards
  - Bugs vs. Aircraft Certification vs. Flight Standards
- "Overcoming inertia:" government and industry
  - Airborne side, limited: pilots, mechanics, Flight Standards
  - Ground side: controllers, maintenance techs
  - Obtaining a new ADS-B radio frequency
- Outcome of risk: schedule slip

Capstone – Journey Through Lessons Learned
Examples:

- Avoid taking newly-developed, newly certified avionics directly into aviation commercial service
- Avoid using firm, fixed price contracts without providing for remedies
- Do provide adequate training and cross-communications
- Be prepared for surprises, set aside resources to fix

Capstone Achievements: FAA's "Skunk Works" for Innovation

- **Achieved air traffic control using the new ADS-B technology in two years**
- **Reduced the accident rate significantly**
  (despite low statistical significance)
- **Nearly 100% commercial equipage in Bethel area**
- **Success story in search and rescue**

Alaska's State motto: "North to the Future"

Next Steps

- **Expand across the state**
- **Investigate ADS-B via satellite for remote regions (Iridium – General Dynamics)**
- **Add TIS-B to ADS-B and FIS-B**
- **Expand into the rest of the NAS (SF-21)**

Alaska aviation at work – Talkeetna Moose Dropping Festival